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Energy Recovery from Domestic and Office Wastes

A RESEARCH REPORT

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Energy Recovery from Domestic and Office Wastes

A RESEARCH REPORT

A Feasibility Study of Energy
Recovery from Domestic and
Office Wastes by On-Site Incineration

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ABSTRACT/RESUME

The study examines the feasibility of recovering energy from office and domestic wastes using on-site incineration.

It is found that the concept is technically feasible, but economically impractical for all but the largest apartment or office buildings.

* * *

La présente étude porte sur la possibilité de récupérer l'énergie résiduelle des ordures ménagères et des rebuts de bureau, grâce à un incinérateur installé sur les lieux.

Il semble que ce soit de fait possible, mais non rentable, sauf dans les très gros immeubles d'appartements ou de bureaux.

Le lecteur trouvera un sommaire, en français, de ce rapport à la page ii.

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This report analyses the types and quantities of wastes which are generated in office and apartment buildings in Canada. The feasibility of recovering energy from these wastes is examined, and an economic analysis is undertaken to assess the viability of the concept, for both retrofit applications, and new construction.

Information contained herein was based on data obtained before April 1, 1982, when the report was first prepared. Caution must therefore be exercised in interpreting financial projections which are presented. Trade names which are used in this report are intended for identification purposes only and do not imply product endorsement.

Finally, it should be noted that the subject matter will only be of interest to a limited audience - managers of large apartment or office buildings. The market sector for which energy recovery from domestic and office wastes were found to be viable is limited to apartment buildings with more than 3,000 units, and office buildings with more than 75,000 square metres and absorption cooling. Such buildings are extremely rare in Canada.

Les ordures ménagères des tours d'habitation et le papier mis au rebut dans les immeubles de bureaux peuvent constituer une source précieuse d'énergie. A l'heure actuelle, la plupart des propriétaires d'immeubles doivent payer pour faire enlever ces déchets.

L'Ontario Research Foundation a donc entrepris une étude afin de déterminer la quantité de rebuts produits et le potentiel calorifique de ces déchets, les techniques d'incinération et de récupération de chaleur en usage, l'état actuel des systèmes privés d'incinération permettant la récupération de chaleur, de même que l'économique du procédé.

Il ressort de son étude :

* Qu'il est possible de récupérer la chaleur résiduelle des rebuts et qu'il existe, pour les immeubles d'appartements et de bureaux, du matériel d'incinération sur place permettant de récupérer la chaleur résiduelle;

* Qu'il existe du matériel qui satisfait aux normes relatives à l'environnement;

* Que l'incinération sur place aux fins de la récupération de chaleur ne pourrait être rentable que dans les immeubles d'appartements abritant 3 000 personnes ou plus;

* Que l'incinération sur place aux fins de récupération de chaleur ne pourrait être rentable que dans les immeubles de bureaux d'une superficie globale de quelque 75 000 m^2 à tout le moins.

Le projet CANWEL de Toronto est un immeuble d'appartements où l'on incinère les ordures ménagères sur les lieux.

Le seul immeuble de bureaux équipé d'un incinérateur à récupération de chaleur, dont on connaît l'existence au Canada, est l'immeuble de la place Gulf Canada à Calgary.

Un autre incinérateur doit être installé à l'usine de la Pratt and Whitney, à Montréal, à la fin de 1982 ou au début de 1983.

Domestic wastes from high rise apartment buildings, and paper wastes from office buildings represent a valuable source of energy. However, in most cases, building owners must pay disposal companies to have these wastes taken away.

There is a potential for on-site incineration of these wastes to produce energy for heating and cooling which could then be used to displace energy from conventional sources.

Historically, incineration has been plagued with problems. In the past, incinerators generally polluted the atmosphere with undesirable gases, particulates and obnoxious odours. For these reasons, most incinerators in older buildings are not used and new buildings generally are constructed without incinerators.

Incinerator manufacturers have worked on the development of their products to the point where they feel they have managed to overcome the previous problems associated with incinerators. With the addition of suitable heat recovery equipment, systems for the recovery of energy by on-site incineration can be constructed.

Other factors which improve the attractiveness of on-site incineration include rising landfill, waste transportation, and disposal costs in addition to increasing energy costs.

Because of these developments, the recovery of energy from waste may become attractive for high rise apartment and office buildings.

This project was undertaken to evaluate the technical and economic feasibility of utilizing the energy content of domestic and office wastes through on-site incineration with heat recovery. The following key areas are addressed:

1. An evaluation of the composition, quantities and heating values of domestic and office wastes.

2. A review of current incineration and heat recovery techniques.

3. A "state-of-the-art" survey of equipment for incineration of, and heat recovery from, office and apartment building wastes.

4. A preliminary economic evaluation of energy recovery from waste for a variety of sizes of office and apartment buildings.

To assess the potential recoverable energy from wastes, and the technology required for recovery, it is necessary to know the quantities, composition and heat content of the wastes that are likely to be encountered.

2.1 Characteristics of Typical Domestic and Office Wastes

A literature survey was carried out to gather information on waste characteristics. Very little data was found on the typical composition and heating values of both domestic and office wastes. CSA standard Z103-1976, Incinerator Performance [1], gives higher heating values (HHV) of wastes according to standarized classification, as shown in Table 2.1. The HHV of average domestic waste is shown as 14.68 MJ/kg.

The composition of domestic wastes from 1 apartment building in Toronto is available from a study carried out in the 1970's [2]. The characteristics of the waste analysed for that study are shown in Table 2.2, with a HHV of 11.62 MJ/kg.

Since the HHV for the above mentioned apartment building was the only value found for an actual apartment wastes, and is a more conservative value than cited by CSA, the HHV of 11.62 MJ/kg is used for the purposes of calculation in this study.

Table 2.1. Characteristics of Domestic Wastes

Material	HHV MJ/Kg Dry Basis	Moisture Weight Per Cent Wet Basis	Weight Per Cent of Total Waste	CSA Type Weight Per Cent of Total Waste							
				A	B	C	D	F	G	I	M
Paper, mixed	17.61	10.24	42.0	42.00							
Wood and bark	20.02	20.00	2.4		2.4						
Grass	17.89	65.00	4.0			4.0					
Brush	18.37	40.00	1.5		1.5						
Greens	16.46	62.00	1.5			1.5					
Leaves (ripe)	16.44	50.00	5.0			5.0					
Leather	20.58	10.00	0.3						0.3		
Rubber	26.35	1.20	0.6					0.6			
Plastics	33.42	2.00	0.7				0.7				
Oils, Paints	31.17	0.00	0.8								0.8
Linoleum	19.33	2.10	0.1				0.1				
Rags	17.80	10.00	0.6	0.6							
Sweepings(street)	13.96	20.00	3.0		3.0						
Dirt(household)	8.81	3.20	1.0	1.0							
Unclassified	6.98	4.00	0.5	0.5							
Garbage	19.73	72.00	10.0			10.0					
Fats	38.84	0.00	2.0								2.0
Metallics	0.29	3.00	8.0							8.0	
Glass and Ceramics	0.15	2.00	6.0							6.0	
Ashes	9.70	10.00	10.0							10.0	
Total refuse	14.68	19.74	100.0	44.1	6.9	20.5	0.8	0.6	0.3	24.0	2.8

Table 2.2. Wet-Based HHV of Domestic Wastes from a Toronto Apartment Building [2], Based on CSA Classification of Composition

CSA Type	Average HHV MJ/Kg Wet Basis	Weight Per Cent of Total Waste	Contribution to total HHV MJ/Kg
A	15.54	44.1	6.85
B	12.82	6.9	0.88
C	7.34	20.5	1.50
D	31.02	0.8	0.25
F	26.35	0.6	0.16
G	20.58	0.3	0.06
I	3.76	24.0	0.90
M	36.65	2.8	1.02
Total HHV, MJ/Kg			11.62

The relation between dry-based and wet-based heating valve is:

$$\text{Dry-based heating valve} = \frac{\text{As received (wet-based) heating valve}}{1 - (\text{per cent moisture content})}$$

For office building wastes, the only information that was found was of waste from a commercial enterprise as tabulated in the CSA standard Z103-1976 Incinerator Performance [1]. This information is listed in Tables 2.3. and 2.4.

Quantities of wastes generated for both office and apartment buildings are given in the publication "Criteria for Incinerator Design and Operation" published by the Department of Energy and Resources Management of Ontario in 1970 [3]. According to this publication, the approximate quantities of waste generation are 0.05 kilograms per square metre of floor space per day for office buildings, and 2 kilograms per occupant per day for apartment buildings. The bulk densities of the waste varies with compaction. The office waste density is estimated to be approximately 160 kilograms per cubic metre, and the domestic waste density is estimated to be 320 kilograms per cubic metre.

2.2 Domestic and Office Wastes as an Energy Source

Apartment building and office wastes have certain characteristics which render them attractive for on-site energy conversion. The waste is at the same location as the energy required, and no cost is incurred in transportation. Also, disposal costs are much less for the ash from the incinerator than for the raw waste, and the waste has a fairly high energy content.

Table 2.3. Characteristics of Office Wastes

Material	Weight Per Cent of Total Waste	CSA Type Weight Per Cent of Total Waste			
		A	D	E	I
Paper, mixed	40	40			
Pallets and crates	20	20			
Polyethylene	8		8		
PVC	2			2	
Metals	10				10
Glass	10				10
Sweeping, dirt	10	10			
Total Wastes	100	70	8	2	20

Table 2.4. Calculation of the Wet-Based HHV of the Office Wastes

CSA	Average HHV MJ/Kg Wet Basis	Weight Per Cent of Total Waste	Contribution to total HHV MJ/Kg
A	18.61	70	13.02
D	44.19	8	3.53
E	23.26	2	0.46
I	-	20	-
Total HHV, MJ/Kg			17.01

A generalized schematic for an incineration system with heat recovery is shown in Figure 3.1. The actual system will contain the incinerator and heat recovery unit, and may or may not have an emission control unit, depending on the characteristics of the system. The solid effluent discharge is the unburned material from the incinerator, which must be disposed of. An overview of the technology applicable to each of these components is described below.

3.1 Incineration Technology

There are a number of possible methods for burning of waste to recover energy. Historically, single chamber units were used for many building applications. These units tended to have high levels of particulate and odour emissions which made them unacceptable. Because of these problems, manufacturers developed multiple chamber controlled air incinerators. Other incinerator types include fluidized bed, catalytic, rotating drum, and cyclonic incinerators. However, these are more suited to large industrial users. The multi-chamber unit appears to be the most suitable for application in apartment and office buildings and for this reason will be described in more detail.

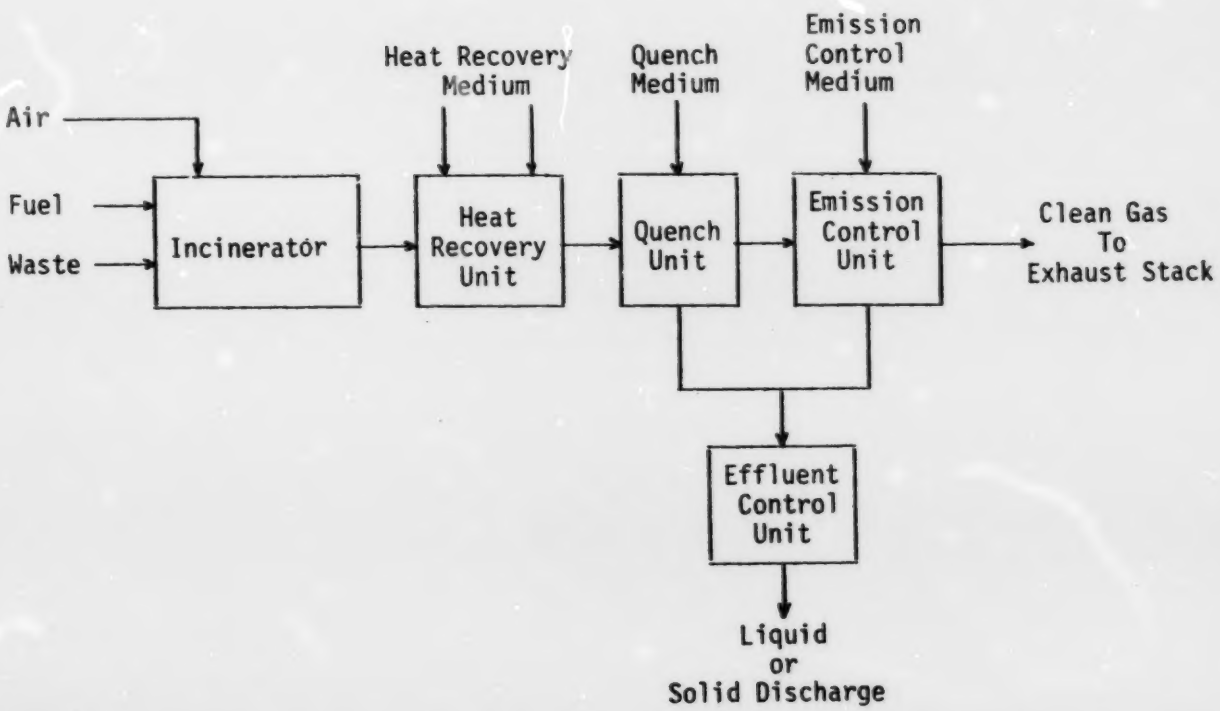

FIGURE 3.1 GENERALIZED WASTE TO ENERGY INCINERATION SYSTEM

3.1.1 Multiple Chamber Controlled Air Incinerator

Figure 3.2 shows a schematic of a multi-chamber controlled air incinerator. As the name implies, this type of incinerator has two or more chambers in which the incineration process takes place. There are two groups of controlled air incinerators.

For both types raw waste is first loaded into the primary chamber either by hand or by automatic ram feeding devices. An auxiliary burner using natural gas or fuel oil is used to dry the refuse and to ignite it. Once the temperature in the primary chamber reaches the minimum level for acceptable operation, the auxiliary burner is shut off. The burner is then cycled on only when required to maintain the chamber temperature above the minimum requirement.

For a type 1 starved air incinerator, the amount of combustion air fed to the primary chamber is controlled to produce partial combustion only. For a type 2, or excess air incinerator, the amount of combustion air is controlled to promote complete combustion.

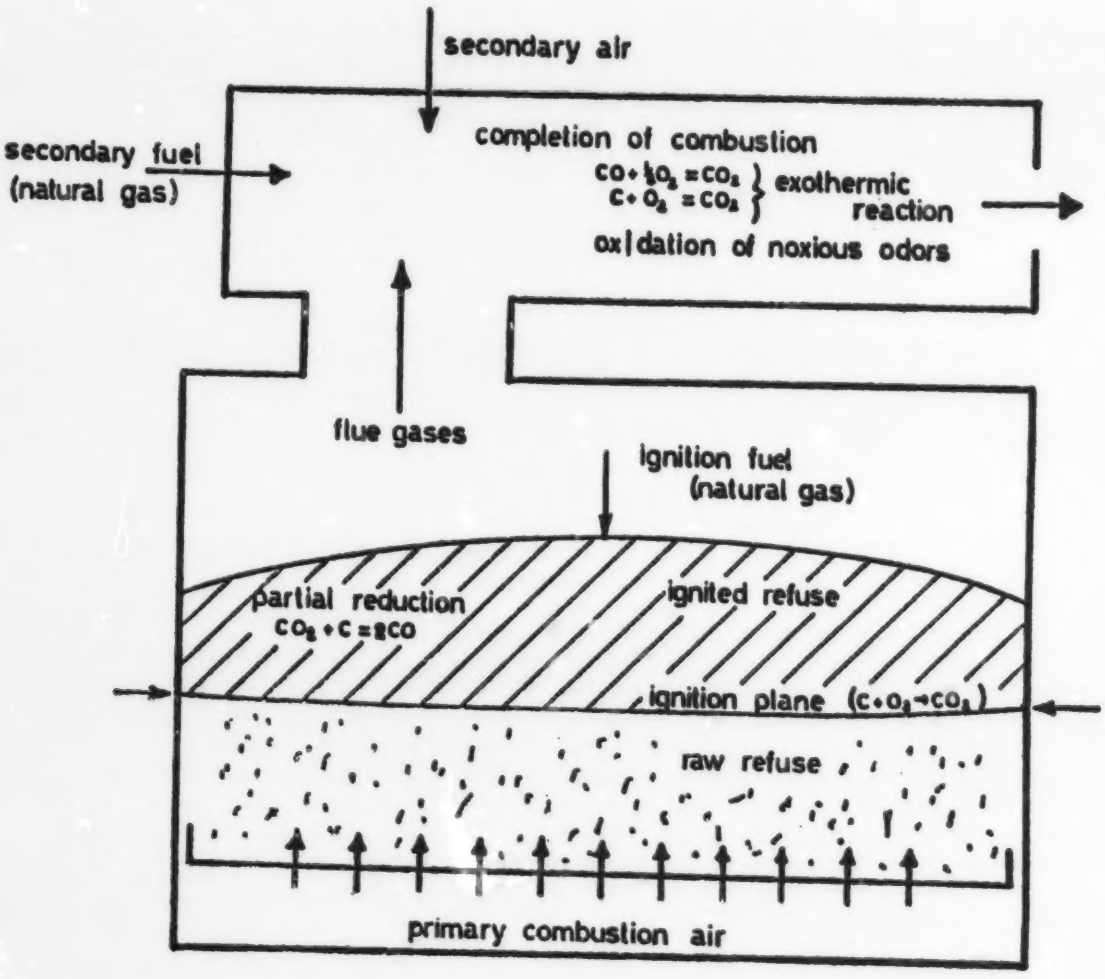

FIGURE 3.2. SCHEMATIC OF CONTROLLED AIR INCINERATION

In a starved air incinerator, an auxiliary burner is used to ignite partially burned gases in the secondary chamber. As in the primary chamber, when the temperature in the secondary chamber is above a required minimum, the burner is shut off. Secondary air is introduced into this chamber to ensure completion of the combustion process.

In an excess air incinerator, the secondary chamber is used for combustion of gases or particulate not completely burned in the primary chamber due to insufficient residence time. The temperature of the gases leaving the primary chamber is usually high enough that a secondary auxiliary burner is not required.

The secondary chamber in an excess air incinerator is basically used to provide the additional residence time needed for complete combustion of particulates and unburned combustible gasses leaving the primary chamber.

Controlled air incinerators are available for use with both domestic and office waste. The secondary chambers are effective in controlling odours and particulates usually associated with incineration of domestic wastes. With office wastes, past problems with escape of small pieces of paper have been significantly reduced or eliminated by keeping air velocities low and the increased residence time provided by the secondary chamber.

3.2 Heat Recovery Technology

Increasing energy costs have led to the development of a number of waste heat boilers for energy recovery from hot exhaust streams. These boilers are similar in design to conventional boilers and can be used for producing hot water, low pressure steam, or even high pressure steam. For most office and apartment building applications, hot water or low pressure steam would be appropriate. Heat recovery units can be located in the exhaust stack of the incinerator, or they can be connected to the incinerator stack through ducts. In the latter case, a bypass arrangement is used, where the exhaust gases either go directly up the stack, or are forced through the heat recovery unit using fans, depending on exhaust temperatures and heating requirements.

3.3 Emission Control

Typical emissions that can be expected from an incinerator burning apartment and office wastes include carbon monoxide, hydrogen chloride, sulphur dioxide, nitrous oxides, particulate matter and hydrocarbons. The allowable levels of emissions will be dependent on the jurisdiction in which the incinerator is located, and the stack parameters. If it is not possible for the incinerator to achieve these levels, emission control equipment must be installed. This equipment could consist of scrubbers, precipitators, or filters, depending on the nature of the emissions. Scrubbers have been developed which are effective for incinerators burning apartment building waste [4].

4.1 Manufacturers

A list of manufacturers was compiled from a published EPA study [5], trade directories and advertisements. Canadian manufacturers were initially contacted by telephone to solicit information. A total of eight manufacturers supplied information on incineration and heat recovery systems.

A listing of all manufacturers contacted is given in Appendix A. The letter sent to each is given in Appendix B.

Appropriate capacities of incinerators were assumed to be up to 5 000 kilograms of waste per day, which would represent an apartment complex containing about 2 500 persons, or an office building with a floor area of 100 000 square metres. Seven of the eight manufacturers have equipment which falls into this range. Table 4.1. summarizes the available equipment from these 7 manufacturers.

All but one of the manufacturers use starved air type incinerators. Heat recovery equipment is available for reclaiming heat as either hot water or steam. Most incinerators and heat recovery units are manufactured on a modular approach, where components are factory installed into a package which can be easily installed in a building. Various options are available including automatic feeding equipment and ash removal systems.

TABLE 4.1. MANUFACTURERS AND EQUIPMENT OF WASTE-TO-ENERGY INCINERATION SYSTEMS

Manufacturer	Available Models	Loading System	Combustion Process	Type of Heat Recovery	Emission Control Equipment	Auto-Deashing Equipment	Capacity kg/Day
Trecan	7	Batch Semi-continuous	Starved Air	Hot Air Hot Water Steam	Not Required	N/A	36 to 6 080
Centro	5	Batch Semi-continuous Continuous	Starved Air	Hot Water Steam	Not Required	Available	900 to 20 000
Kelley	8	Batch Continuous	Starved Air	Hot Water Steam	Not Required	N/A	2 300 to 70 000
Basic Environmental	7	Semi-continuous Continuous	Excess Air	Hot Air Hot Water Steam	Required If Necessary	Available	4 500 to 120 000
Burn-Zol	5	Semi-continuous Continuous	Starved Air	Hot Air Hot Water Steam	Required	Available	up to 24 000
International Waste	11	Batch Sem-continuous Continuous	Starved Air	Hot Water Steam	Required If Necessary	Available	180 to 37 000
Washburn & Granger	7	-	Starved Air	Hot Air Hot Water Steam	Required	-	180 to 24 000

4.2 Existing Installations in Canada

During the survey of manufacturers, the representatives were asked whether there were any on-site incineration systems with heat recovery in office or apartment buildings in Canada. The only system of which they were aware is the Canwel waste incineration system, installed in an apartment building in Toronto.

Further research revealed that the Canada Square Corporation has installed an incinerator with waste heat recovery in the Gulf Canada Square office building in Calgary, Alberta. Also, Pratt and Whitney are planning to install a paper waste incinerator at their plant in Montreal. A description of these systems based on available data is presented below.

4.2.1 Canwel Apartment Building Incineration System

The Canwel (Canadian Water and Energy Loop) concept is an integrated domestic waste management and energy reclamation system. After research and pilot plant studies, a first generation commercial prototype was installed in 1977 in a Toronto high rise apartment building with an approximate population of 1 000 people.

Figure 4.1. shows a schematic of the system. The system essentially consists of the following:

- Material conveying, storing and feeding system
- Dual chamber controlled air incinerator
- Waste heat reclamation hardware

- Ventilation and fire protection system

- Automatic control with safety interlocks.

The first step in the system is material handling. Here garbage from the collection chute is transported to a storage feeder. An automatic hydraulic ram feeds the incinerator at an average rate of 100 kg/hr.

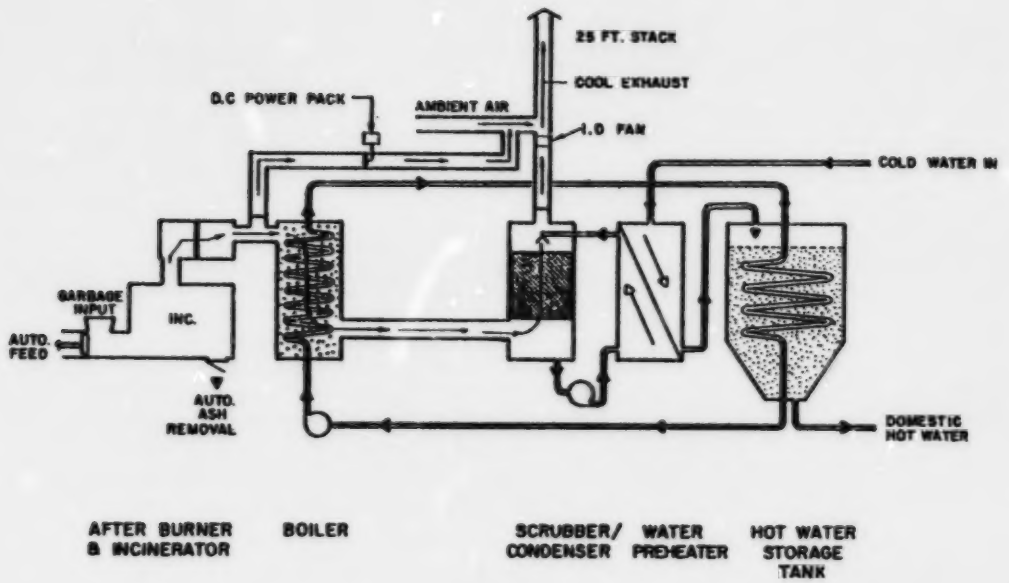

FIGURE 4.1. INCINERATION AND HEAT RECOVERY PROCESS SCHEMATIC

The incinerator is of the multiple chamber controlled air type, with a capacity of up to 100 kg/hr of waste. A commercially available waste heat boiler is used to recover approximately 530 megajoules per hour to produce domestic hot water at 60 C. A scrubber is used to clean and cool the exhaust gases so that they can be discharged through a 7.6 metre high stack. Stack emissions are all below Ontario regulations.

4.2.2 Gulf Canada Square Office Building Incinerator System

The Gulf Canada Square building incineration system in Calgary is a prototype on-site office waste incinerator with heat recovery.

The system was installed three years ago in the 120 000 square metre building and has been undergoing developmental work since then.

The system uses a controlled air incinerator with a capacity of 200 to 450 kilograms per hour. The unit has a conventional heat recovery boiler. The boiler produces 1 000 kilowatts of steam which is used to operate a 1 000 kilowatt absorption chiller. The incinerator is fully automated and is located on the top floor of the building. The emissions meet the standards of the Province of Alberta.

4.2.3 Pratt and Witney

Pratt and Whitney are planning to install a 570 kg/hr incinerator at their plant in Montreal. The wastes burned in this unit will consist of paper, wood, cardboard and waste oil. The heat recovered from the incinerator will be used to produce steam for heating.

The incinerator selected is a two chamber Trecan model. No additional pollution control equipment is expected to be needed.

It is anticipated that the system will be installed in late 1982 or early 1983.

In the preceding section of this report it was shown that on-site incineration of apartment building and office building wastes appears to be technically feasible, based on equipment presently available from manufacturers. The economics of these systems will now be examined.

Present off-site disposal of wastes is expensive due to high transportation, labour, and landfill costs. Average disposal costs in the Toronto area for domestic garbage are about $1.00 for 50 kilograms, and about $1.00 for 30 kilograms of office waste, based on information received from waste disposal companies. Thus, for a 1 000 person apartment building generating 2 000 kilograms of waste per day, annual disposal costs would be about $14 600.

Since waste is available on a year-round basis, and cannot be stored for long periods of time, a fairly constant end use for the energy product must be found. In apartment buildings, an appropriate use of the energy produced is domestic hot water production. According to data obtained from Cadillac Fairview Corp., about 9 gigajoules of energy are required per person per year for domestic hot water heating [6]. As previously stated, the amount of waste generated per person is approximately 2 kilograms per day, with an energy content of about 11.6 megajoules per kilogram. Incinerator manufacturers estimate that about 65% of the energy in the waste can be recovered. Thus, the waste produced by each person could be used to provide 5.5 gigajoules of energy per year, about 60% of the annual energy needs for heating domestic hot water.

For some office buildings, heat is used on a year-round basis; for space heating in winter and absorption cooling in summer. At an average waste generation rate of .05 kilograms per square metre per day, with a calorific value of 17 megajoules per kilogram, the energy produced from the waste would be 144 megajoules per square metre per year. As a comparison, Ontario Hydro [7] estimates that on average, 1 700 megajoules of total energy per year are required for one square metre of office space, with approximately 50% of this, or 850 megajoules, used for space heating. Thus there is more than enough use for the energy produced by the incinerator.

5.1 On-site Incineration for Apartment Buildings

To evaluate the economic feasibility of using on-site incineration and heat recovery in apartment buildings, estimates of equipment, installation, and operating costs were made for a range of building sizes and incineration systems. Savings were calculated for reduced waste disposal costs, and for natural gas displaced for domestic water heating. Results of the analyses are presented in Table 5.1.

The sizes of building chosen were selected to correspond with capacities of incineration systems manufactured by one Canadian company. For smaller buildings, batch loading systems were considered. In this type of operation, the incinerator is filled with waste manually, then the burn cycle is carried out. After the waste load has been burned the incinerator is cooled and the ashes removed manually. For larger units, a ram feed device is used to push waste into the incinerator. Automatic ash removal units are only constructed for large municipal type units, and are not available for smaller units.

The operating hours for the incinerators are limited to 6 hours for the batch load units, and 10 hours for the ram feed units because of the ash removal requirements.

The following is a description of the information used in preparing the economic analyses for the apartment building incinerator.

5.1.1. Building sizes were selected based on available incinerator sizes. Waste generation was assumed to be 2 kilograms per person per day, with a calorific value of 11.6 megajoules per kilogram.

5.1.2. Costs for incineration and heat recovery equipment, and its operation and maintenance were based on information provided by Trecan Ltd. Labour costs were based on $18 000 per man-year [8].

TABLE 5.1. ECONOMIC ANALYSIS FOR RESIDENTIAL BUILDING WITH 6 HOUR AND 10 HOUR OPERATION PER DAY, 365 DAYS PER YEAR

	6-Hour Operation Per Day		10-Hour Operation Per Day	
Occupants	320	1 027	1 210	3 365
Waste Stream (Kg/day)	640	2 055	2 420	6 730
Apartment Configuration	One 10-Fl Apt. Bldg.	One 35-Fl Apt. Bldg.	Two 20-Floor Apt. Complex	Four 28-Floor Apt. Complex
Equipment Cost ($)				
Incinerator) Heat Recovery)	70 000	110 000	60 000	94 000
Stack ($)	14 000	24 000	12 000	20 000
Feeder ($)	NA/(Batch)	NA/(Batch)	25 000	25 000
Installation Cost: New	77 000	77 000	77 000	77 000
Installation Cost: Retrofit	155 000	155 000	155 000	155 000
Operation Cost				
Labour (man)	.25	.25	1	1
Fuels ($)	2 000	3 000	2 500	5 000
Ash Removal ($)	467	1 500	1 767	4 913
Maintenance and Repair Cost ($)	2 520	4 200	2 910	4 170
Yearly Waste Stream (kg)	233 000	750 075	883 300	2 456 450
Annual Energy Recovery (GJ) at 65% Overall Efficiency	1 694	5 441	6 164	17 142
Equivalent Gas Worth (m^3)	44 974	144 408	170 055	472 923
Energy Savings ($)	-7 196	-23 105	-27 209	-75 668
Disposal Savings ($)	-4 672	-15 001	-17 666	-49 129
Net Annual Savings ($)	-2 381	-24 789	-19 698	-92 714
Simple Payback Time: New (Year)	67.6	8.8	8.8	2.3
Simple Payback Time: Retrofit (Year)	100.4	11.9	12.8	3.2

5.1.3. The stack costs depend on the height of the stack and the diameter of the stack. The incinerator capacity determines the required stack diameter. The height of stack needed depends on the incineration system emission characteristics. For this study, it was assumed that 40 feet of stack would be adequate. This would allow for installation of a stack similar to that used for the CANWEL system [4], or would allow for connection to an existing unused incinerator stack. Construction of a new stack for the full height of the building was not included, as this would greatly increase the cost of the installation.

5.1.4. The installation cost for the incineration system is based in information from the CANWEL Project [4]. Costs were updated using the Statistics Canada Construction Index [9].

5.1.5. The overall heat recovery efficiency of the incineration process was estimated to be 65%. This is based on manufacturer's claims.

5.1.6. The cost used for natural gas was $0.16 per cubic metre, based on information supplied by Consumer's Gas [10].

5.1.7. The average waste disposal cost for domestic waste is $20 per tonne. This is based on average costs for the Toronto area for a 2.3 cubic metre bin, with a waste density of 320 kilograms per cubic metre [11].

5.1.8. It was assumed that the incineration system requires no additional pollution control equipment.

The economic analysis shows that paybacks for incinerators would be greater than 5 years for all cases except the largest complex with 3 365 persons. For this case, a new installation would have an estimated payback of 2.3 years, and a retrofit installation would have a payback of slightly over 3 years.

5.2 On-site evaluation for Office Buildings

A preliminary economic evaluation for on-site incineration and heat recovery for various office building sizes was carried out. Savings were calculated for reduced waste disposal costs and for natural gas displaced for space heating and cooling. The results of the analysis are shown in Table 5.2.

TABLE 5.2. ECONOMIC ANALYSIS FOR OFFICE BUILDING AT 6 HOUR AND 10 HOUR PER DAY, 260 DAY PER YEAR OPERATION

	6-Hour Operation Per Day		10-Hour Operation Per Day	
Floor Area (m^2)	16 360	40 000	36 400	68 000
Waste Stream (Kg/Day)	818	2 000	1 820	3 400
Equipment Cost				
Incinerator Heat Recovery ($)	94 000	134 000	70 000	94 000
Stack ($)	20 000	28 000	14 000	20 000
Feeder ($)	N/A(Batch)	N/A(Batch)	25 000	25 000
Installation Cost: New ($)	77 000	77 000	77 000	77 000
Installation Cost: Retrofit ($)	155 000	155 000	155 000	155 000
Operation Cost				
Labour (man)	.25	.25	1	1
Fuels ($)	3 000	4 100	3 333	5 000
Ash Removal ($)	532	1 300	1 183	2 210
Maintenance and Repair Cost ($)	3 420	4 860	3 270	4 170
Yearly Waste Stream (kg)	212 680	520 000	473 200	884 000
Annual Energy Recovery (GJ) at 65% Overall Efficiency	2 350	5 746	5 229	9 768
Equivalent Gas Worth (m^3)	62 373	152 500	138 774	25 925
Energy Savings ($)	-9 980	-24 401	-22 204	-41 480
Disposal Savings ($)	5 317	13 000	11 830	22 100
Net Annual Savings ($)	-3 845	-22 641	-8 248	-34 200
Simple Payback: New (Year)	50	10.6	22.6	6.3
Simple Payback: Retrofit (Year)	70	14.0	32.0	8.6

As for apartment buildings, the size of office building selected was based on available incinerator capacities. Batch loading for smaller buildings and ram feeding for larger buildings were considered.

The information and assumptions used in making this analysis are described below.

5.2.1. Building sizes were selected based on available incinerator sizes. Waste generation was assumed to be .05 kilograms per square metre of floor area, with a calorific value of 17 megajoules per kilogram. Waste generation was assumed to occur 260 days per year.

5.2.2. Costs for incineration and heat recovery equipment, and its operation and maintenance were based on information provided by Trecan Ltd. Labour costs were based on $18 000 per man year [8].

5.2.3. The stack costs depend on the height of the stack and its diameter. For this study it was assumed that 40 feet of stack would be adequate. This would allow for installation of the incinerator on the top floor of the office building, where HVAC equipment is often located.

5.2.4. The installation cost for the incineration system is based on information from the CANWEL project [4]. Costs were updated using the Statistics Canada Construction Index [9].

5.2.5. The overall heat recovery efficiency of the incineration process was estimated to be 65%, based on manufacturer's claims.

5.2.6. The cost used for natural gas was $.16 per cubic metre, based on information supplied by Consumer's Gas [10].

5.2.7. The average waste disposal cost for office waste is $33 per tonne. This figure is based on average costs for the Toronto area for a 4.6 cubic metre bin with a waste density of 160 kilograms per cubic metre [11].

5.2.8. The incinerator system requires no additional pollution control equipment.

The economic analysis shows that payback for incinerators would be in excess of five years for all cases. The lowest payback was 6.3 years for an installation in a new office building of 68 000 square metre floor area.

Based on the studies and analyses carried out, the following conclusions were reached:

Domestic and office wastes are a valuable source of energy.

It is technically feasible, and equipment is available for on-site incineration of wastes, with heat recovery in apartment and office buildings.

Energy produced from the wastes can be used to displace conventional fuels for domestic water heating in apartment buildings, and for space heating and cooling in office buildings.

Equipment is available which can meet environmental standards.

A preliminary economic analysis shows that an on-site incineration and heat recovery system for apartment buildings would have a payback of 3.2 years for retrofit in a building complex of 3 365 persons. The payback for installation in a new building of similar size would be 2.3 years. The payback time is greater for smaller size buildings.

For office buildings, the preliminary economic analysis shows that payback would be greater than 5 years for buildings of 68 000 square metres or less. The payback for a 68 000 square metre building would be 6.3 years for a new building, and 8.6 years for a retrofit installation.

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Domestic and Office Waste

The Ontario Research Foundation is currently conducting a preliminary study to evaluate the technical and economic feasibility and practicability of utilizing the energy content of domestic and office waste. Our objective will be to demonstrate to building owners (medium and high rise residential and office buildings) the cost effectiveness and the energy conservation potential associated with this technology.

We would appreciate if you could provide ORF with the current "State-of-the-Art" in incineration and controlled air, partial pyrolysis and heat recovery technologies and the pertinent costs of your products.

Your prompt response will be much appreciated.

Yours truly,

John Liou
Assistant Research Scientist
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JL/ek